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Research Article

Assessment of household adaptive capacity to disasters: Two comparative case studies in Central Vietnam

Nguyen Thao Ly[1,2], Tran Thi Huong[1], Yuki Ishikawa - Ishiwata[1,3], Nguyen Thuy Duong[1], Nguyen Thu Hien[4], Yeshus Umesh[1], Nguyen Thi Hoang Ha[1]*

[1] VNU Vietnam Japan University, Vietnam; thaolyn97@gmail.com; huongtt.vngecc@gmail.com; yuki.ishikawa.ga@vc.ibaraki.ac.jp; nt.duong@vju.ac.vn; yashuscc@gmail.com
[2] The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH; thaolyn97@gmail.com
[3] Global and Local Environment Co-creation Institute (GLEC), Ibaraki University; yuki.ishikawa.ga@vc.ibaraki.ac.jp
[4] Department of Climate Change, Ministry of Natural Resources and Environment; thuhien7585@gmail.com

*Corresponding author: nth.ha@vju.ac.vn; hoangha.nt@vnu.edu.vn; Tel.: +84–968046008

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Abstract: This paper presents comparative case studies between an ancient town in Quang Nam province (QN town), and a commune in Da Nang city (DN commune) in order to quantitatively assess the adaptive capacity of households in response to natural disasters. An indicator-based assessment with a set of 13 indicators is applied in this study. The results of 85 interviewed households in two study areas revealed that despite the higher probabilities of disaster occurrence, the households in QN town demonstrated better adaptive capacity compared to those in DN commune. The quantitative assessment (on a 0–1 scale) of adaptive capacity in the QN town and DN commune showed the values of 0.61 and 0.55, respectively. QN town had higher adaptive capacity than DN commune due to higher income stability, better preparedness measures for disasters, higher percentages of households receiving disaster warning information, better accessibility to clean water, healthcare service, food, and financial support during and after disasters. Conversely, DN commune demonstrated higher insurance coverage, higher percentages of households participating in social organizations, and receiving social support during and after disasters. Drawing from the findings that influence the difference in adaptive capacity levels between households in QN town and DN commune, the study subsequently proposes the recommendations for policymakers and individuals in both areas to improve their long-term prevention and preparedness strategies, enabling them to effectively respond to natural disasters.

Keywords: Adaptive capacity; Disaster; Indicator; Household; Vietnam; Vulnerability.

1. Introduction

Natural hazards are defined as environmental phenomena that pose possible impacts on societies and the human environment, especially in developing countries where the community faces greater exposure and vulnerability to climate-driven disasters [1]. As the threat of climate change continues to grow, it is imperative for human society to prioritize both mitigation and adaptation strategies in response to disasters [2]. Furthermore, it is recognized that natural disasters increase vulnerability to climate change, simultaneously

diminishes the ability to withstand risks, shocks, and stresses. Therefore, it is essential to enhance adaptive capacity by promoting and supporting adaptive measures, contributing to reduction of climate change vulnerability [3]. Adaptation entails developing the capacity to adjust system components, structures, and processes in response to anticipated or observed long-term changes, such as alterations in the frequency of hazardous events [4]. It is, therefore, crucial to comprehend, evaluate, and enhance adaptive capacity in order to facilitate adaptive measures and mitigate climate change impacts [5].

A variety of studies assessed the adaptive capacity to disasters using both secondary data and primary data (e.g., interviews, surveys, and focus group discussion) [6]. Specifically, Bossio et al. [7] identified the adaptive capacities in urban areas, underscoring the significance of governance and social institutions in shaping urban adaptive capacity. Recognizing the limitations of existing investments in improving the understanding of adaptive capacity in tropical coastal communities, Cinner et al. [8] proposed an approach that encompassed five key domains to build adaptive capacity, including assets for resilience, flexibility in strategies, collective organization, and action, learning and responsiveness to change, and agency in decision-making, while also highlighting strategies for their development. Nguyen et al. [9] identified significant variations in adaptive capacity across different regions in Vietnam, highlighting specific areas that require urgent attention to enhance their resilience to typhoons, which can inform national disaster risk reduction initiatives and guide the development of effective mitigation strategies for long-term sustainability. Aalst [10] also supported Nguyen et al. [9] that even though the households were highly vulnerable due to climate change, it is possible to enhance the resilience of the households by targeting the policy measures for the specific socioeconomic groups.

Gaining insights into and evaluating the adaptive capacity at the local level is necessary to initiate an understanding of how it can be fostered through broader development initiatives at both local and national scales [6]. Furthermore, households play a critical role within the intricate socio-natural system and are susceptible to the impacts of climate change. Therefore, conducting research on climate change adaptation at the household level is crucial for developing effective strategies to enhance adaptation and reduce vulnerability [11]. However, despite the critical role that household-level decisions play in shaping local and systemic vulnerability, there is a scarcity of research focused on assessing adaptive capacity to historical disaster events, particularly at the household level [6, 12].

Vietnam ranks among the world's most vulnerable countries to natural hazards [13]. Due to its geographic location and geographical conditions with a long coastline of 3,240 km, Vietnam has unique climate features, causing severe and diverse disasters in this area [14]. Accordingly, the country experiences high levels of exposure to disasters [3, 14]. Typhoons and floods are the most frequent hazards, impacting roughly 59% of Vietnam's landmass and affecting around 71% of its population [15]. Located downstream of the Vu Gia–Thu Bon River system in the South-Central Coast areas, Da Nang city and Quang Nam province have experienced several severe typhoons, floods, and inundation [16]. Meanwhile, the occurrence and severity of natural disasters have recently risen because of the influence of climate change [16]. The heightened frequency of intense rainstorms poses a significant threat of devastating floods to urban communities in Da Nang city, causing exacerbated social and physical damage in this area [16]. Despite reports of relatively high adaptive capacity among Da Nang city's urban households [11, 17], the historical typhoon-induced inundation that struck the city in October 2022 caused severe damage to human lives and properties [18]. This fact highlights the understanding of how households can adapt to exceptional disasters. Meanwhile, the increasing occurrence of severe floods in Quang Nam province has also significantly impacted communities' livelihoods and socio-economic development [19]. Additionally, within Quang Nam province, roughly 1.3% of the area is susceptible to flooding, with Hoi An city facing the highest risk (25.4% of the area), followed by Tam Ky (17.7% of the area) if the sea level rises

by 100 cm [20]. This climate-driven impact could exacerbate the annual inundation in these areas. The comparison of adaptive capacity to disasters between areas affected by high and low frequency of serious inundation may provide important implications for enhancing adaptive capacity of households.

This study aims to assess the adaptive capacity of households in response to natural disasters, focusing on typhoons, floods, and inundation in one of the most affected communes in Da Nang province and an ancient town in Quang Nam province, hereafter DN commune and QN town, respectively. The findings from this research are expected to provide valuable insights to inform the development of adaptation policies and guide municipal governance in these specific areas.

2. Materials and methods

2.1. Study areas

DN commune, located in the northwest of Da Nang city (Figure 1), is home to an average population of 47,338 people [21]. It is subjected to a tropical monsoon climate, with a rainy season from August to December and a dry season from January to July [17]. Furthermore, being part of Da Nang city, the commune is characterized by diverse topography, including mountains in the west and lowlands in the east, which contributes to increased flooding due to the proximity of the mountains to the coastline [22]. As a result, the study area frequently experiences severe disasters and extreme weather events [17, 22].

QN town is located on a coastal plain at the estuary of the Thu Bon River basin, in central Vietnam. The town's altitude varies from 70 to 517 meters above sea level, situated within a hot and humid tropical monsoon climate characterized by rainy seasons [23]. Accordingly, QN town, positioned in a low-lying delta near an estuary and coastal environment (Figure 1), is vulnerable to various natural impacts, with the primary threat being floods during rainy seasons due to changes in land use in the town and surrounding areas which are exacerbated by approximately 25% of Vietnam's typhoons affecting the area [23, 24].

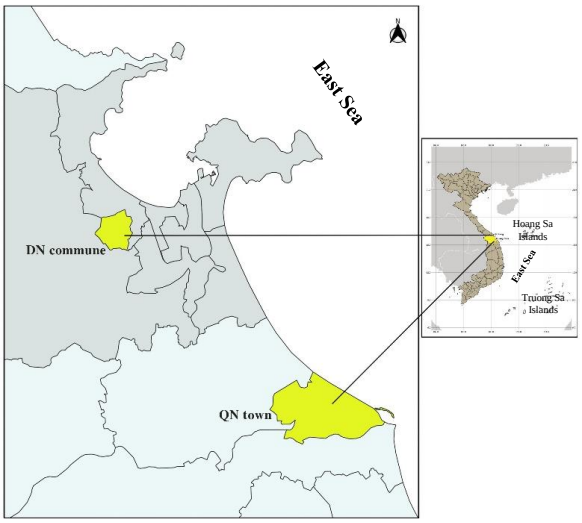

Figure 1. The study areas in DN commune and QN town.

2.2. Theoretical framework and indicator-based assessment

Adaptive capacity refers to the capability of systems, institutions, humans, and other organisms to adapt and respond to potential damages, capitalize on opportunities, and address the consequences of change [25]. The process of adaptation necessitates the ability to learn from past experiences in order to effectively manage the current climate conditions and apply those lessons to cope with future climate changes, even in the face of unexpected events. Therefore, to assess the preparedness and adaptation of systems to climatic events, it would

be necessary to examine multiple time periods encompassing the period before, during, and after the event [26]. According to Engle [27], if the system underwent adaptation or adjustment, regardless of whether it suffered negative consequences from the prior event, it implies the presence of inherent capacity to do so. Consequently, examining the factors that either facilitated or hindered these adaptations, as well as where they occurred or did not occur, can enhance comprehension of adaptive capacity dynamics.

However, our understanding of adaptive capacity is continuously evolving, and there is currently a lack of consensus regarding its distinct characteristics and determinants at the national, community, or household level [28]. In addition, the successful implementation of adaptation strategies necessitates various resources, such as financial, social, human, and natural capitals. The specific types of required resources, and their relative significance depend on the context in which adaptation is pursued, the nature of the hazards faced, and the characteristics of the adaptation strategy itself [29]. To tackle this challenge, various methods have been developed to assess adaptive capacity, utilizing an indicator-based approach. Ramieri et al. [30] assessed coastal vulnerability using a range of independent variables, merged into a composite index covering drivers, risks, hazards, exposure, sensitivity, impacts, adaptive capacity, and damage. It enables a thorough evaluation of various coastal vulnerability aspects within a unified assessment framework. In addition, 19 indicators, emphasizing diverse aspects such as economic resources, infrastructure, social capital, institution, were identified and considered crucial elements in measuring adaptive capacity to assess the adaptive capacity of farmers in Mexico [31]. Mai et al. [11] developed a set of 17 indicators to assess the socio-economic status of urban households, focusing on inherent capacity and municipal services for urban area stability and security.

In this paper, a composite indicator framework [32] using 13 indicators for quantitative assessment of adaptive capacity was proposed (Table 1; Figure 2). Indicators were selected based on their relevance, methodological soundness, and data reliability, availability and accessibility [32]. Indicators (AC2–AC7) were referenced from Mai et al. [11], other indicators were proposed to measure the adaptive capacity in a timely manner for the historical disaster event in October 2022 affecting the study areas for proactive adaptation of future events (Figure 2).

Table 1. Indicators for adaptive capacity assessment in two study areas.

Code	Indicators	Descriptions	Calculation
AC1	Income stability	Accessibility to income stability during disasters	Equation (1)
AC2*	Livelihood diversity	Number of livelihood sources per household	Equation (1)
AC3*	Housing condition	Categories of housing conditions based on structure, permanence, and number of floors	Equation (1)
AC4*	Insurance coverage	Percentage of households with health insurance Percentage of households with property insurance	Ratio (%)
AC5*	Education	Number of people who have graduated above secondary level	Equation (1)
AC6*	Preparedness measures	Number of disaster mitigation tools equipped by households	Equation (1)
AC7*	Social organizations	Number of social organizations that household members are affiliated	Equation (1)
AC8	Social support	Percentage of households receiving support during and post-disasters	Ratio (%)
AC9	Disaster warning information	Percentage of households receiving disaster warning information	Ratio (%)
AC10	Accessibility to clean water	Accessibility to clean water during and post-disasters	Equation (1)
AC11	Accessibility to healthcare service	Accessibility to healthcare service during and post-disasters	Equation (1)
AC12	Accessibility to food	Accessibility to food during and post-disasters	Equation (1)
AC13	Accessibility to financial support	Accessibility to financial support during and post-disasters	Equation (1)

Note: *Mai et al. [11].

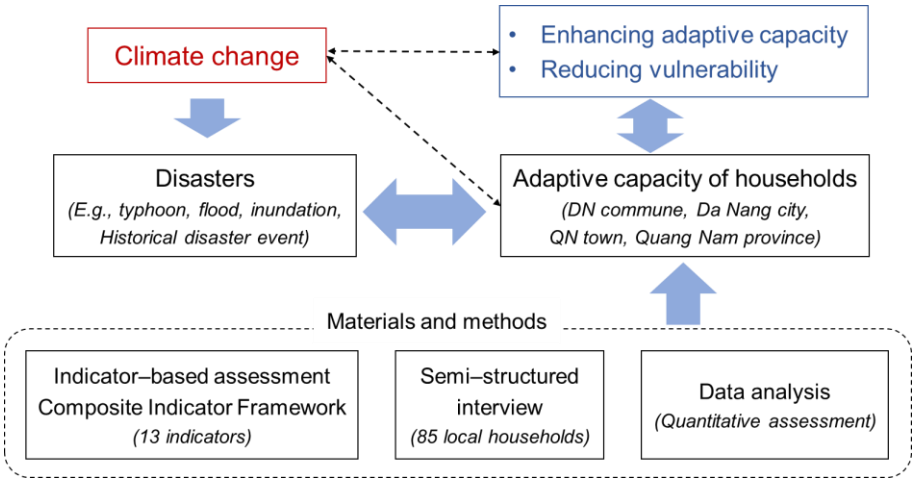

Figure 2. Framework for indicator-based assessment of adaptive capacity to disasters.

2.3. Sociological survey

The questionnaire was developed in accordance with the proposed indicators for assessing adaptive capacity (Table 1). A semi-structured interview using a face-to-face method was conducted in the case study areas (Figure 2). A total of 85 households in DN commune and QN town were randomly selected to ensure a relatively even spatial distribution, various levels of impacts by disasters, and diversity of livelihoods.

2.4. Data analysis

The data corresponding to the indicators were coded, normalized by the Min-Max method (on a 0–1 scale) [33] using Eq. (1) as follows:

$$x_{ij} = \frac{X_{ij} - MinX_{ij}}{MaxX_{ij} - MinX_{ij}} \quad (1)$$

where, x_{ij} is the normalized value of indicator i of the household j; X_{ij} is the value of the indicator i corresponding to household j; Max and Min denote the maximum and minimum scaled values of indicator i, respectively.

Adaptive capacity of households to disasters in each study area was measured as follows:

$$AC = \frac{\sum_1^n AC_i}{n} \quad (2)$$

where, AC is the adaptive capacity of households to disasters; AC_i is the adaptive capacity measured by indicator i; n is the number of indicators.

The quantitative adaptive capacity levels of households to disasters in each study area were evenly classified based on a Likert scale (1–5) and a categorical scale by the OECD [32], as shown in Table 2 [34].

Table 2. Adaptive capacity assessment scale.

No.	Adaptive capacity level	Score
1	High adaptive capacity	0.81 – 1.00
2	Relatively high adaptive capacity	0.61 – 0.80
3	Medium adaptive capacity	0.41 – 0.60
4	Relatively low adaptive capacity	0.21 – 0.40
5	Low adaptive capacity	0.00 – 0.20

Quantitative assessment of adaptive capacity of households to disasters was conducted using Excel. A correlation coefficient was performed for correlation among 13 indicators using the SPSS 20.0 package.

3. Results

3.1. Adaptive capacity of households to disasters

Income stability (AC1): The results from interviews showed that over 39.5% of households located in DN commune were unable to access income stability during disasters, while 31.6% of interviewees in QN town encountered similar difficulties (Figure 3). Moreover, approximately 34.2% of households in QN town had full access to stable income. In contrast, only 9.3% of those in DN commune had a fully stable income during disasters.

Livelihood diversity (AC2): A majority of households in two study areas had one livelihood (88.6–92.5%) (Figure 4). QN town had a slightly higher percentage of households with at least two types of livelihoods compared to DN commune, corresponding to 5% and 4.5%, respectively (Figure 4). However, there was a larger proportion of households with no income source in DN commune, accounting for about 6.8% of total interviewees in that area, compared to QN town, where only 2.5% of households reported unstable income sources (Figure 4).

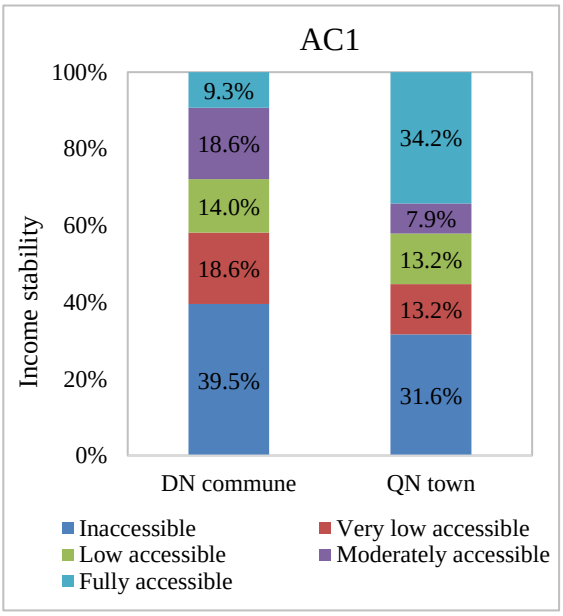

Figure 3. Percentage of households accessible to income stability during disasters (%).

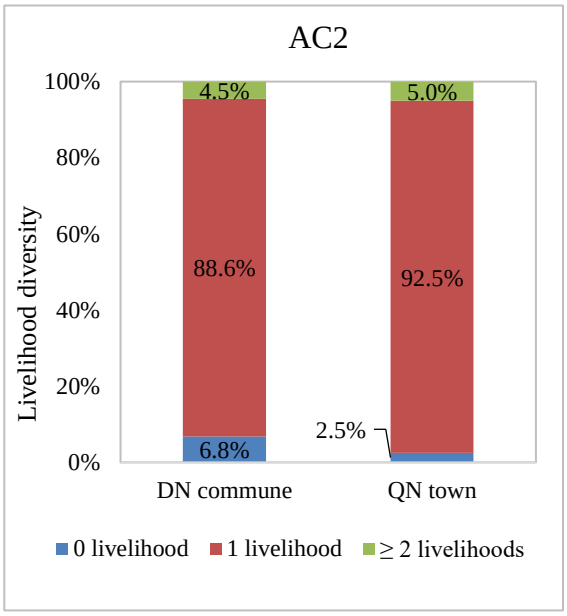

Figure 4. Percentage of households with number of livelihoods (%).

Housing condition (AC3): As located in the ancient heritage area, households in QN town were prohibited from renovating their houses, resulting in a significant proportion of IV-type houses and III-type houses, accounting for 62.5% and 32.5%, respectively (Figure 5). Meanwhile, despite being situated in the economic development and urbanization area, the proportion of IV-type houses among the interviewed households in DN commune was higher than that in QN town, accounting for 72.7% of interviewees. Additionally, the rate of temporary houses was also significantly higher in DN commune compared to QN town, with approximately 13.6% and 2.5%, respectively.

Insurance coverage (AC4): Most interviewees in DN commune and QN town participated in health insurance, with 84.1% and 77.5%, respectively (Figure 6). Meanwhile, none of the interviewees in both areas participated in property insurance, possibly due to a lack of awareness and understanding about the importance and benefits of property insurance, particularly regarding the risks associated with potential property damage or loss from natural disasters.

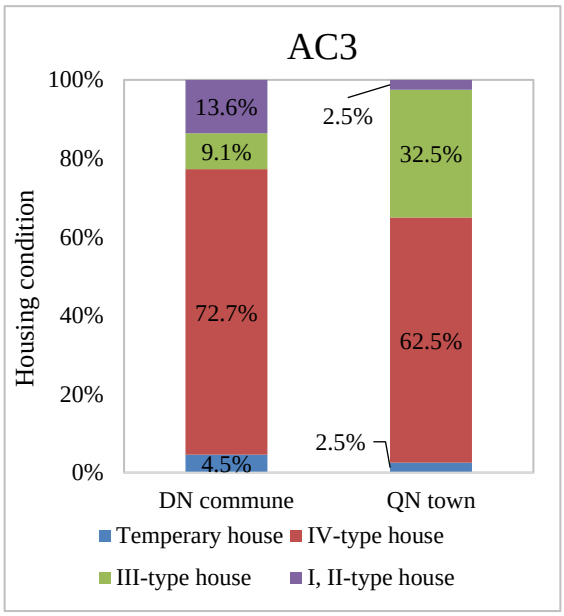

Figure 5. Percentage of households with various housing condition categories (%).

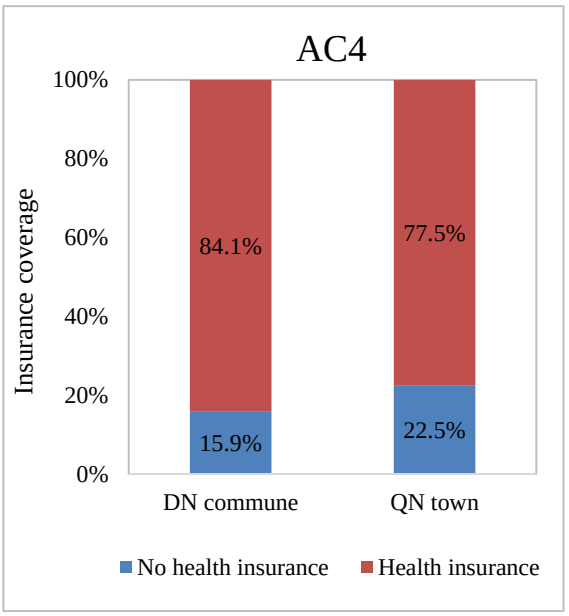

Figure 6. Percentage of households with health insurance coverage (%).

Education (AC5): Most of the interviewees in DN commune and QN town had a secondary degree or higher (Figure 7). The percentage of interviewees who have graduated above the secondary level in QN town was only 18.4%, while in DN commune, the figure was slightly higher at about 20.9% (Figure 7).

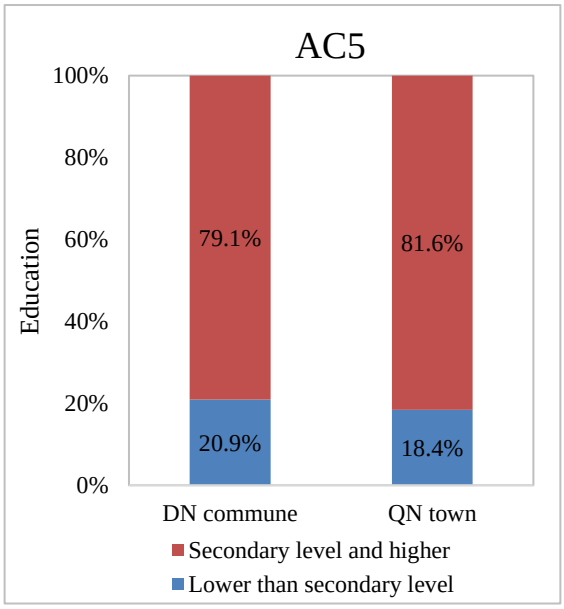

Figure 7. Percentage of interviewed people with education level (%).

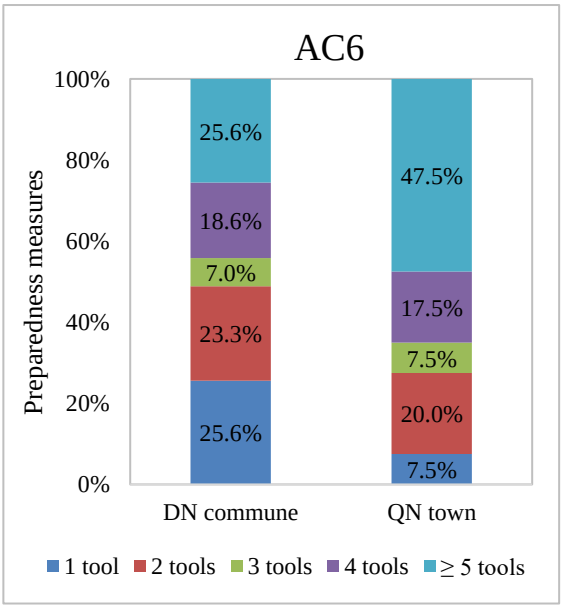

Figure 8. Percentage of households equipped with disaster mitigation tools (%).

Preparedness measures (AC6): Approximately 47.5% of interviewed households in QN town were equipped with more than 05 disaster adaptation tools, while in DN commune, only 25.6% of interviewees had the same level of preparedness (Figure 8). According to the interview results, it is notable that a large majority of the interviewees have been long-term residents of QN town with nearly 98% residing there for over a decade. In contrast, in DN commune, around 40% of the households interviewed had a relatively shorter period of residency, being residents for less than 10 years (Figure 8). It could be seen that the sampled

households living in their current residence for a longer duration were more likely to have a higher possibility of taking better preparedness measures.

Social organization (AC7): The survey results showed that most of the interviewees in QN town did not participate in social organizations (83.8%), whereas in DN commune, the participation rate was higher, with more than 32.6% of the total interviewed households being involved in social organizations (Figure 9).

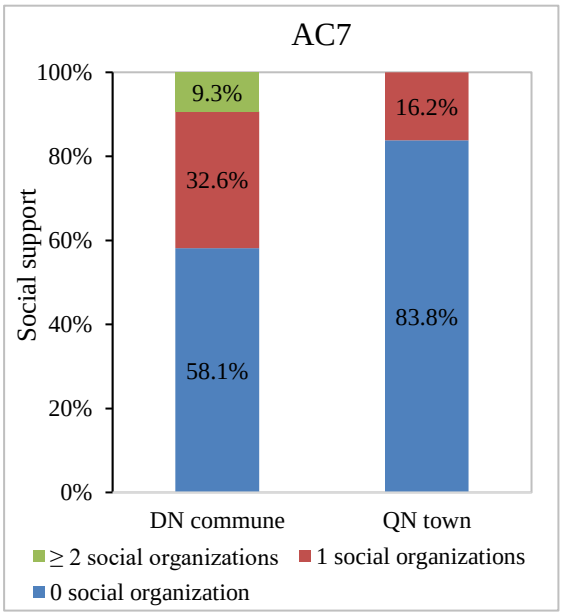

Figure 9. Percentage of households participated in social organizations (%).

Social support (AC8): In DN commune, 68.3% of households reported receiving no social support during disasters (Figure 10), causing a lack of preparedness and resources to cope with the challenges posed by disasters. On the other hand, in QN town, a higher percentage of households, which accounted for 85%, indicated a similar absence of social support. In addition, in terms of social support after disasters, DN commune had a higher percentage of households with access to support after disasters, accounting for 53.7% of interviewees, compared to QN town, where only 32.5% of households had access to support (Figure 10). The interview indicated that in QN town, where floods occur frequently, both the local government and people were experienced in dealing with extreme weather events, reducing the need for extensive support. However, in DN commune, where inundation was less common, local authorities may be less proactive in their response due to lower frequency.

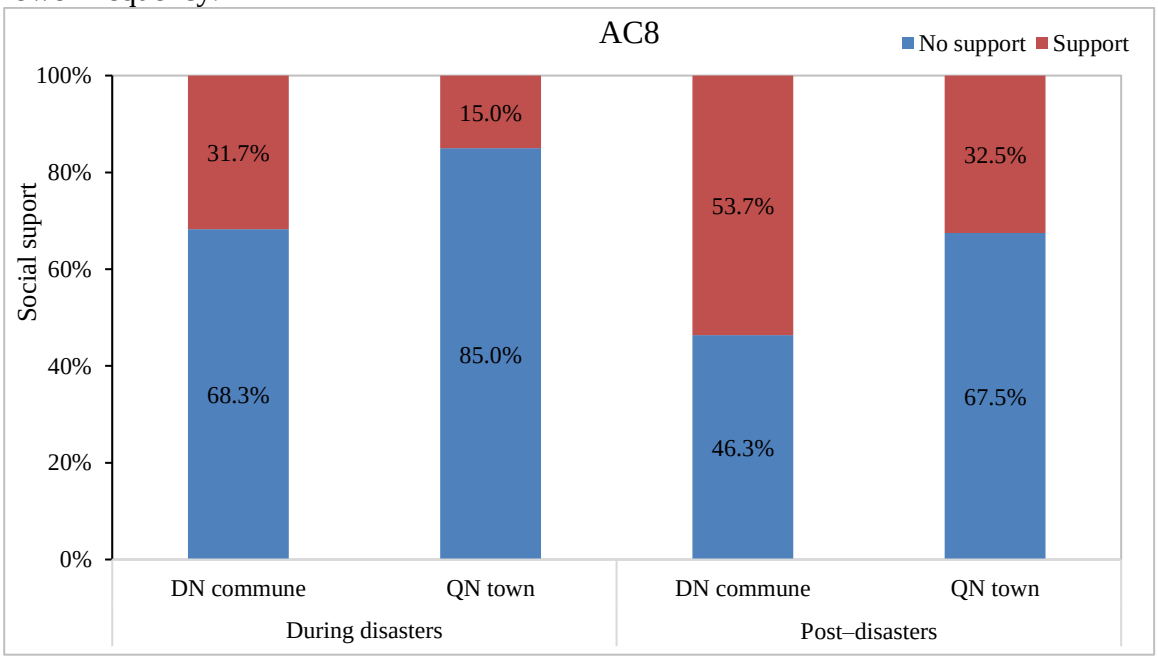

Figure 10. Percentage of households receiving support during and post-disasters (%).

Disaster warning information (AC9): Most interviewees in both DN commune and QN town, approximately 85.2% and 97.1% respectively, reported receiving disaster warning information (Figure 11).

Accessibility to clean water (AC10): 57.5% of interviewees had full access to clean water, the percentage in DN commune was dramatically lower, with only 18.2% having full access to clean water during disasters (Figure 12). After the disasters, the percentages of households fully accessible to clean water increased to 64.7% and 29.7% in QN town and DN commune, respectively (Figure 12). The difference in access to clean water between QN town and DN commune may be attributed to various factors. In QN town, houses with additional garrets provide shelter and minimize damage during disasters. However, households in DN commune lacked renovation options and faced challenges in disaster response. Timely information and disaster response experience also differed between the two areas.

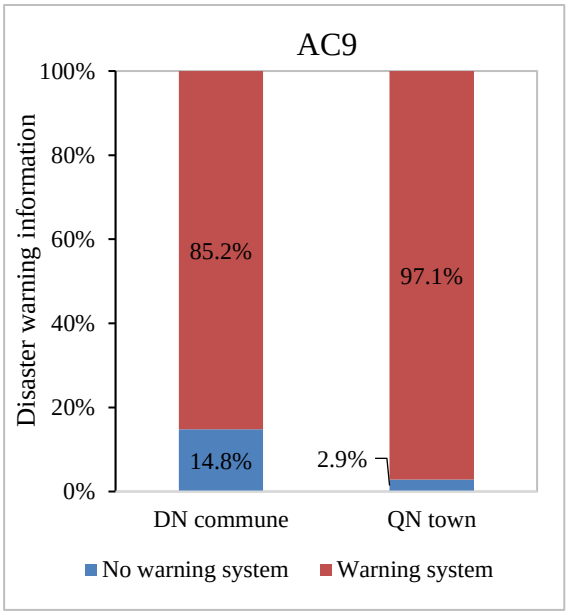

Figure 11. Percentage of households receiving disaster warning information (%).

Accessibility to healthcare service (AC11): The percentage of households in QN town and DN commune fully accessible to healthcare service during the disasters were 65.0% and 25.6%, respectively (Figure 13). We also found a high percentage of households in DN commune inaccessible to healthcare service during the disasters (37.2%), mainly resulting from the historical disaster in October 2022. Approximately 76.5% of interviewees located in QN town had full access to healthcare (AC11) after natural disaster events. Meanwhile, in DN commune, the figure was significantly lower, with only 47.1% having access to healthcare. The interview indicated that the households in QN town were well-acquainted with the flood situation in the region. Consequently, they prepared by stocking up on food and taking steps to relocate the elderly or vulnerable family members to hospitals nearby.

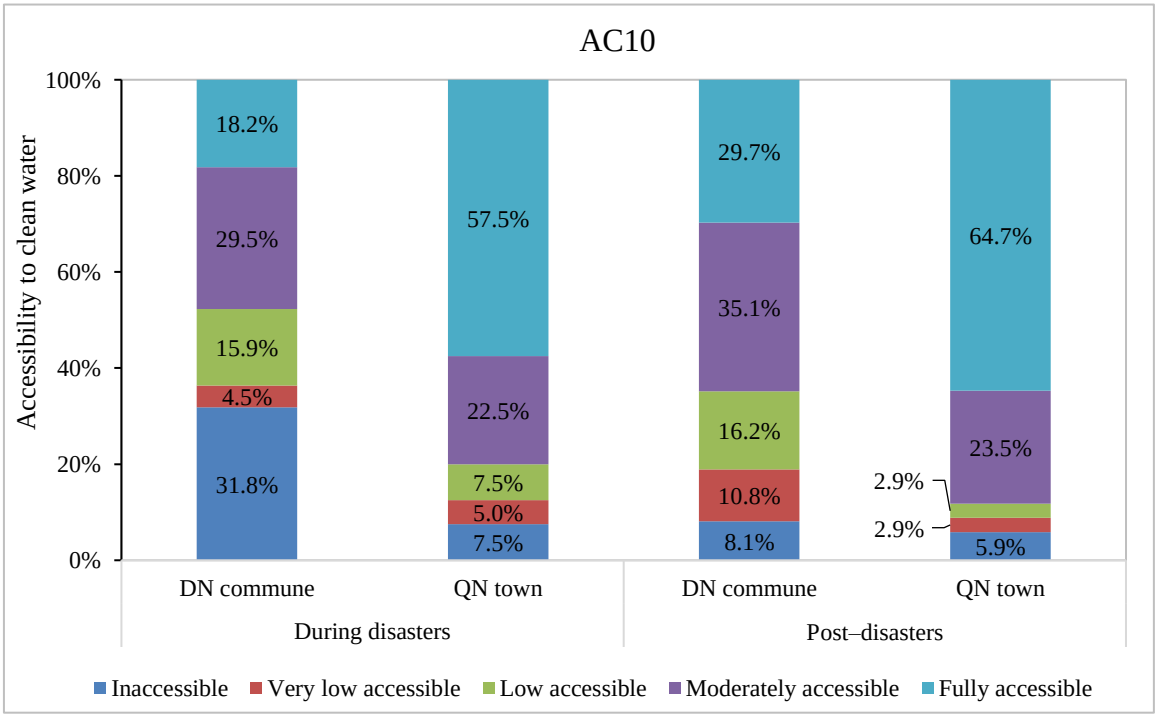

Figure 12. Percentage of households accessible to clean water during and post-disasters (%).

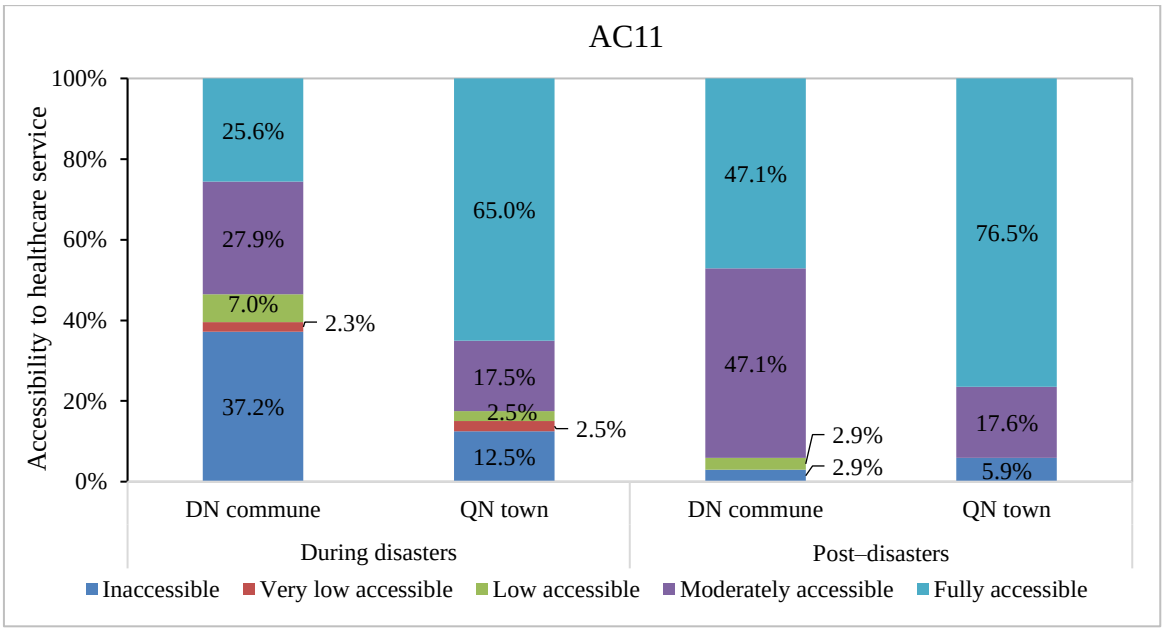

Figure 13. Percentage of households accessible to healthcare service during and post-disasters (%).

Accessibility to food (AC12): The interview results of this study showed a high percentage of households (72.5–78.1%) in QN town having full accessibility to food during and after disasters, implying a good response to high frequency of disaster in this area (Figure 14). In DN commune, percentages of households that had moderate and full accessibility to food during and after disasters were 64.5% and 87.5%, respectively (Figure 14).

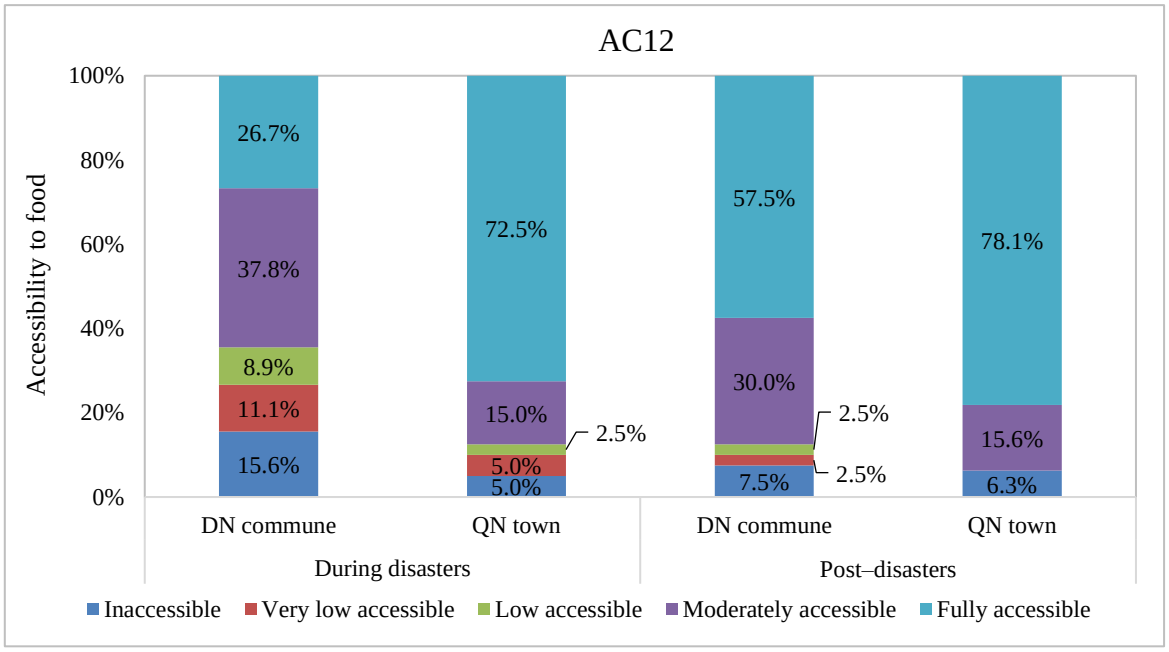

Figure 14. Percentage of households accessible to food during and post-disasters (%).

Accessibility to financial support (AC13): The result demonstrated high percentages of households in DN commune (65.8%) and QN town (52.8%) who were not accessible to financial support during disasters (Figure 15). After the disasters, 50% of interviewees in DN commune reported not receiving any financial support, while the figure for QN town was lower at 29% (Figure 15). Furthermore, only about 9.4% of households in DN commune fully accessed financial support, while in QN town, the percentage was higher at 19.4% (Figure 15).

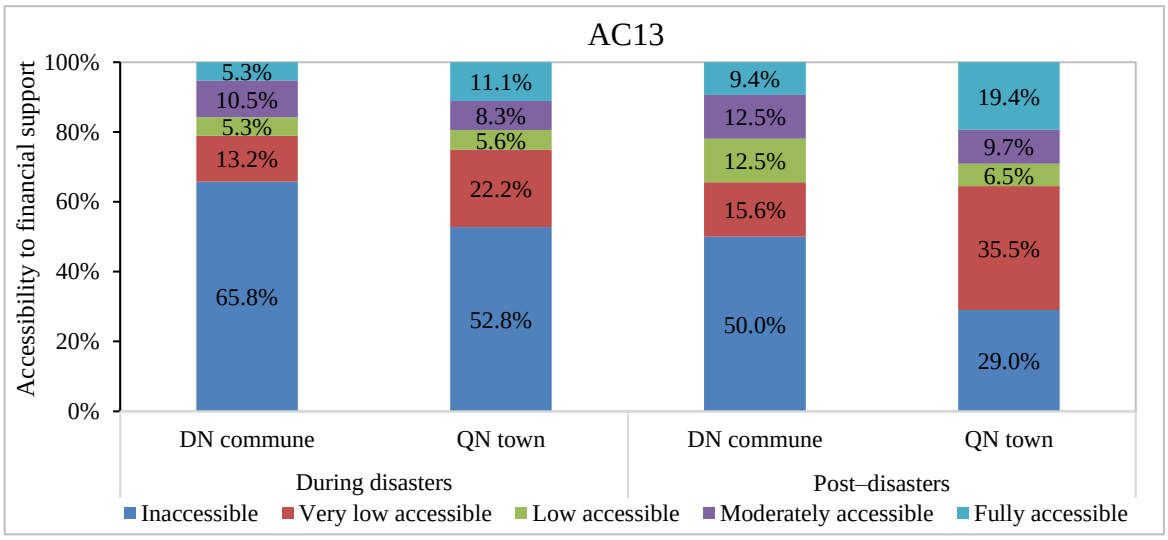

Figure 15. Percentage of households accessible to financial support during and post-disasters (%).

The averages of adaptive capacity variables are shown in Figure 16 for households in two study areas. In which, QN town was assessed at relatively high adaptive capacity with an average value of 0.61, while DN commune stands at medium adaptive capacity with an average value of 0.55. The data showed that both study areas stated the relatively same level of adaptive capacity in livelihood diversity (AC2), housing condition (AC3), and education (AC5) (Figure 16). Meanwhile, QN town had a higher adaptive capacity level compared to DN commune in terms of income stability (AC1), preparedness measures (AC6), disaster warning information (AC9), accessibility to clean water (AC10), healthcare service (AC11), food (AC12), and financial support (AC13) (Figure 16). In contrast, DN commune demonstrated higher adaptive capacity than QN town in terms of insurance coverage (AC4), social organizations (AC7), and social support (AC8) (Figure 16).

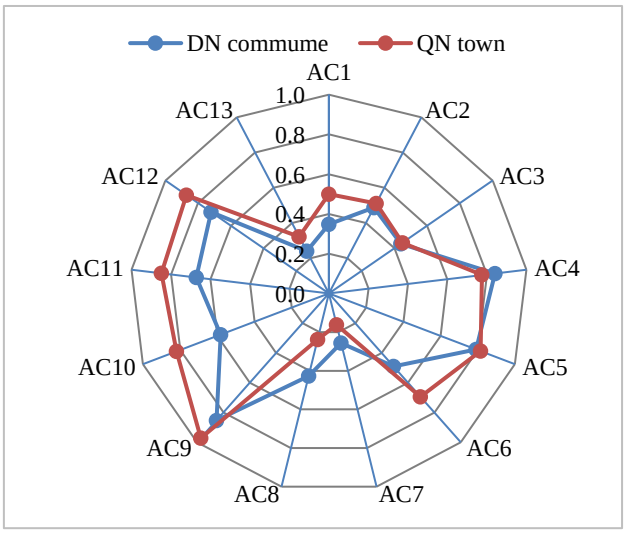

Figure 16. Adaptive capacity of households to disasters.

3.2. Correlation among adaptive capacity indicators

Table shows the correlations among adaptive indicators in DN commune and QN town. The income stability (AC1) was significantly correlated with education (AC5; $r = 0.33$, $p < 0.05$), preparedness measures (AC6; $r = 0.35$, $p < 0.05$), accessibility to clean water (AC10; $r = 0.40$, $p < 0.05$), healthcare service (AC11; $r = 0.43$, $p < 0.05$), and food (AC12; $r = 0.37$, $p < 0.05$). The significant correlation between preparedness measures (AC6) and accessibility to clean water (AC10; $r = 0.31$, $p < 0.05$), healthcare service (AC11; $r = 0.35$, $p < 0.05$) and

food (AC12; r = 0.33, p < 0.05) were also observed. Similarly, insurance coverage (AC4) and financial support during and post–disaster accessibility (AC13) were correlated (r = 0.23, p < 0.05). In addition, accessibility to clean water (AC10) were correlated with accessibility to healthcare service (AC11; r = 0.77, p = 0.05), food (AC12; r = 0.7, p < 0.05) and financial support during and post-disaster accessibility (AC13; r = 0.36, p < 0.05).

Table 3. Correlation coefficients among adaptive capacity indicators of DN commune and QN town.

	AC1	AC2	AC3	AC4	AC5	AC6	AC7	AC8	AC9	AC10	AC11	AC12	AC13
AC1	1.00												
AC2	0.14	1.00											
AC3	0.00	0.00	1.00										
AC4	-0.11	-0.10	0.15	1.00									
AC5	**0.33**	0.20	0.00	0.00	1.00								
AC6	**0.35**	0.15	0.13	0.02	0.15	1.00							
AC7	-0.02	0.06	-0.02	0.22	0.03	0.03	1.00						
AC8	-0.20	-0.05	-0.13	0.15	0.00	0.04	-0.01	1.00					
AC9	0.16	-0.19	-0.06	-0.01	0.01	0.07	**-0.31**	0.14	1.00				
AC10	**0.40**	-0.08	0.14	-0.10	-0.09	**0.31**	**-0.23**	-0.19	0.08	1.00			
AC11	**0.43**	0.04	0.15	-0.05	0.06	**0.35**	-0.13	**-0.23**	0.13	**0.77**	1.00		
AC12	**0.37**	0.02	0.14	0.00	0.08	**0.33**	-0.15	-0.16	0.24	**0.70**	**0.84**	1.00	
AC13	0.23	-0.03	0.16	**0.23**	0.02	-0.07	0.07	-0.16	0.02	**0.36**	**0.25**	**0.30**	1.00

*Pearson correlation significance (p < 0.05) is bold.

4. Discussion

This study utilized an indicator-based method with 13 indicators to evaluate the adaptive capacity of DN commune and QN town to natural disasters, especially typhoons, floods, and inundation. Accordingly, results from the analysis of semi-structured interviews from a total of 85 households in two study areas revealed the complex and complementary interaction among identified adaptive indicators and adaptive capacity of households to respond to typhoons, floods, and inundation. A comparison between DN commune and QN town enhances the understanding of which concepts shaped the ability to deal with climate risks and minimize the loss, thereby contributing effectively to the disaster prevention strategies for the regions.

The results from interviews indicated the low adaptive indicator score in income stability, and a medium average value of livelihood diversity and housing conditions in both study areas. Despite being located in areas of economic development and urbanization, the percentage of households with unstable income was high, leading to a reduction in the ability of households in response to and recovery from the impacts of natural disasters. Meanwhile, the findings of previous studies showed that the lack of economic resources in households leads to susceptibility to disasters due to the difficulties in accessing resources and ability to recover from disasters [35]. Furthermore, an increased level of households with stable income offers greater opportunities for enhancing housing conditions and acquiring durable assets [36]. However, people living in flood-and storm-affected areas in DN town, who often belong to low-income groups, frequently allocate a significant amount of their household income towards housing repairs or reconstruction after the annual floods and storms [37]. Houses situated in low-lying regions often lack safeguards against flooding, such as the absence of upper levels for storing valuable items during floods or the presence of sturdy and weighty roofs that are challenging to open for emergency escape [38]. Moreover, according to the results of interviews, it has been found that due to ongoing local railway construction plans over the past 18 years in DN commune have led to a prohibition on construction or renovation of houses for households living in the surrounding area, making them more vulnerable to natural disaster. A previous study found that individuals with unstable income tend to have a short-term perspective due to urgent and immediate issues that restrict their ability to invest

in housing resilient to typhoons [39]. Furthermore, renovations of houses in QN town are not permitted due to the area's significant historical value and commitment to preserving its ancient character. Thus, these previous findings support the explanation of the results from interviews regarding the medium adaptive indicator score of income stability and housing conditions. However, QN town usually experienced extended bouts of rain and deluges from upstream. When the water level of the Thu Bon River rises, this area is inevitably flooded. Households in QN town, accustomed to these conditions, have proactively implemented adaptation measures, including the construction of additional stories for shelter during floods. In contrast, the interview results indicated that the well-established urban environment and an advanced drainage system in DN commune contribute to a complacent attitude among residents towards inundation, leading to frequent neglect of precautionary actions against this natural calamity.

Previous research indicates that households with education levels beyond secondary are more likely to take preparedness measures [40]. Specifically, individuals with advanced education are increasingly likely to engage in preparedness measures such as their exposure to disasters, involvement in evacuation drills, knowledge about disasters, and the quantity of information sources they access [41]. Based on the findings of research, in comparison to DN commune, households located in QN town possess greater capacity to receive and absorb information and policies from local authorities due to a higher percentage of households having completed education beyond the secondary level. In addition, according to research findings, households located in QN town demonstrated a greater level of experience and higher probability of adopting preparedness measures against disasters than those who located in DN commune. One significant finding of previous research is that the duration of the current residence and the number of past disasters positively influence the probability of adopting preparedness measures [40]. Moreover, past flood experiences are the primary motivators for undertaking preparedness actions [42]. In QN town, the majority of households have resided there for over a decade, with some living in the community for up to 40 years, indicating a strong sense of long-term residency and stability. In contrast, in the DN commune, a significant number of households have relocated from other provinces and are deemed temporary residents. Consequently, DN commune exhibits a low adaptive capacity for preparedness measures, whereas QN town displays a high adaptive capacity of this indicator.

Social networks play a crucial role during the various phases of hazard and disaster events [43]. Sharing experiences among household members and community participation in flood risk reduction can encourage households to adopt proactive preparedness measures [42]. Furthermore, engaging in social networks can enhance knowledge and the capacity to prepare for future natural disasters [44]. Despite receiving warnings about typhoons and floods, households in both study areas demonstrated low to very low adaptive capacity for participating in social organizations, as indicated by their scores. However, the results revealed varying attitudes among households in QN town when discussing this information. They said that due to their extensive experience in flood and inundation preparedness, allowed both households and local authorities to be well-prepared and self-sufficient, eliminating the need for additional support. Conversely, the DN commune's households displayed a passive attitude towards flood prevention due to inadequate preparedness and limited knowledge sharing, leading to greater losses. Therefore, promoting awareness and sharing knowledge and experiences of the impacts and adaptation measures is essential to improve urban households' capacity to manage natural disasters [45].

Moreover, lack of infrastructure maintenance can lead to unsafe conditions and diminish the adaptive capacity to floods [46]. However, households in DN commune have lower adaptive capacity scores regarding food supply, healthcare service and clean water access compared to those in QN town. Interviews revealed that QN town's households adopt

proactive strategies during floods, such as stockpiling food and promptly evacuating vulnerable individuals' elderly, sick, and children to safe areas upon receiving government warnings. Furthermore, sanitary facilities have been installed on the upper floors, demonstrating a high level of accessibility to essential resources, particularly clean water, during flood events. In contrast, households in DN commune face challenges in accessing these resources due to an inadequate drainage system that fails to account for the highest levels of flood risk. Consequently, water is not drained promptly, which exacerbates the situation and hampers rescue and support operations during floods. Beyond the lack of preparedness, households in DN commune endure frequent risks and substantial damage from flooding and inundation, unlike their counterparts in QN town. It is evident in urban areas, characterized by extensive concrete paving, effective floodwater management depends on well-maintained drainage systems, operational pumps, and the availability of water retention areas crucial elements for efficient urban floodwater management [47].

The study findings provide crucial insights for the planning and development policies of both areas, especially DN commune, by identifying following measures to enhance the adaptive capacity of households to natural disasters, thereby reducing vulnerability and curtailing losses, including: (i) Developing flood risk maps, identifying vulnerable regions, and implementing supportive measures such as assisting in the relocation of residents from high-risk zones, enhancing housing as necessary, and assisting low-income households living in temporary houses; (ii) Improving community awareness and practices on climate change and disaster response; (iii) Enhancing support effectiveness via social organizations and training courses on climate change and disaster response; and (iv) Developing concrete provincial urban planning and disaster prevention action plan, that considers varying levels of disaster risks to enhance the efficiency and quality of provincial infrastructures, with particular attention on the drainage system. In addition, DN commune should contemplate aiding local residents in constructing well-designed houses that are adapted for flood resilience and preparedness for historical inundation events.

5. Conclusions

Households in QN town, Quang Nam province, demonstrated relatively high adaptive capacity to natural disasters with a score of 0.61 (on a 0–1 scale), while households in DN commune, Da Nang city, exhibited lower adaptive capacity with a score of 0.55. It is recommended that the adaptive capacity of households located in both areas should be enhanced by implementing strategies, planning, and supportive measures, improving community awareness and practices, and enhancing support effectiveness. Subjectivity in indicator selection, number of indicators, and number of households interviewed were limitations of this research. The survey conducted 3 months after the historical inundation affecting the study areas may underestimate adaptive capacity to normal disaster events. Further studies should be conducted to understand key indicators and key drivers of households' adaptive capacity to disasters.

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